Racial Disparity in Hypertensive Disorders of Pregnancy in New York State: A 10-Year Longitudinal Population-Based Study

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Hypertensive diseases of pregnancy are serious maternal morbidities, occurring in 6%–8% of all pregnancies.[1–3] Gestational hypertension and preeclampsia are risk factors for other forms of maternal morbidities (as well as neonatal morbidity and mortality), making these diseases of reproductive-aged women a particularly important public health problem.[1,2,4,5] Women with gestational hypertension risk progression to severe hypertension, preeclampsia, or eclampsia.[6,7] Women with preeclampsia are predisposed to convulsions, abruptio placentae, disseminated intravascular coagulation, cerebral hemorrhage, pulmonary edema, renal failure, and liver hemorrhage.[2,5,8] Hypertensive disorders in pregnancy are also known to be associated with an increased risk of developing hypertension and stroke later in life.[9] The risks posed by preeclampsia to the fetus include severe growth retardation, hypoxemia, acidosis, premature birth, and death.[1,6] The many risk factors for hypertensive disorders of pregnancy include nulliparity; multifetal gestation; Black race; extremes of reproductive age; obesity; family history of preeclampsia or eclampsia; preeclampsia in a previous pregnancy; presence of diabetes, thrombophilias, essential hypertension, or renal disease[1,8,10–22]; and other contextual factors (e.g., residential poverty).[20–22]

Few population-based studies of maternal morbidities exist. Recent studies have provided insight into risks of pregnancy-induced hypertensive disorders, but large subsets of the population were excluded in evaluations of socioeconomic status (SES), body mass index (BMI), gestational diabetes, or maternal health as cofactors.[10,21,23,24]

We investigated the associations between contextual socioeconomic variables and hypertensive disorders at the time of labor and delivery for a large state population over a 10-year period. Having 10 years of discharge data for New York State (NYS) gave us the opportunity to study the relation between maternal morbidity—specifically hypertension—and factors related to residential poverty and race/ethnicity. We separated New York City (NYC) from the rest of NYS for all analyses, because these regions differ in terms of racial/ethnic structure, population density, economics, geographic characteristics, and health care delivery systems. This study provides insight into how SES and race/ethnicity may each contribute to the risk for hypertension.

METHODS

Data Sources

The NYS hospital discharge database, Statewide Planning and Research Cooperative System (SPARCS), was formed in 1979 for the purpose of monitoring and fiscally managing inpatient and ambulatory hospitalization services in NYS.[25] The statistical variables we chose for this study included *International Classification of Disease, Ninth Revision, Clinical Modification* (*ICD-9-CM*)[26] codes for up to 8 discharge diagnoses (or 15 diagnoses if the patient was discharged in 1994 or later), demographic information (e.g., race, ethnicity, age), type of medical insurance, and zip code of residence.

From the US Census Bureau we obtained 2000 US Census data at the Zip code tabulation area– (ZCTA) level from Summary File 3.[27] ZCTAs are geographic units meant to approximate the boundaries of postal zip codes and comprise groups of census blocks.

Cases

Between 1993 and 2002, 3 120 329 acute care hospital discharges in NYS had a

Objectives. We studied trends of hypertensive disorders of pregnancy by residential socioeconomic status (SES) and racial/ethnic subgroups in New York State over a 10-year period.

Methods. We merged New York State discharge data for 2.5 million women hospitalized with delivery from 1993 through 2002 with 2000 US Census data.

Results. Rates of diagnoses for all hypertensive disorders combined and for preeclampsia individually were highest among Black women across all regions and neighborhood poverty levels. Although hospitalization rates for preeclampsia decreased over time for most groups, differences in rates between White and Black women increased over the 10-year period. The proportion of women living in poor areas remained relatively constant over the same period. Black and Hispanic women were more likely than White women to have a form of diabetes and were at higher risk of preeclampsia; preeclampsia rates were higher in these groups both with and without diabetes than in corresponding groups of White women.

Conclusions. An increasing trend of racial/ethnic disparity in maternal hypertension rates occurred in New York State during the past decade. This trend was persistent after stratification according to SES and other risk factors. Additional research is needed to understand the factors contributing to this growing disparity. (*Am J Public Health.* 2007;97:163–170. doi:10.2105/AJPH.2005.068577)

pregnancy-related diagnostic, procedure, or diagnostic-related grouping *ICD-9-CM* code.[25] We selected records with codes for a delivery, excluding 417 279 hospitalizations of pregnant women for reasons other than delivery.

We excluded hospitalizations if we could not obtain residential information because the woman resided outside NYS (n=50 892) or was incarcerated (n=2145), the zip code was changed or removed by the post office during the study period (n=5020) or was otherwise unmatched with 2000 US Census data (n=1385), or no poverty information was available for the zip code (n=131). We also excluded hospitalizations if the woman was younger than 15 or older than 54, or if age was missing (n=34 673). Finally, we excluded those hospitalizations where the woman had a pregnancy terminated by miscarriage or spontaneous or induced abortion (n=29 467), had a diagnosis of HIV or AIDS (n=8242), or had a diagnosis of both type 1 and type 2 diabetes (n=26). The final study sample consisted of 2 571 069 (95% of total records with codes for a delivery) hospitalizations with delivery.

We assessed 5 hypertensive outcomes: essential hypertension (preexisting hypertension), gestational hypertension, preeclampsia, severe preeclampsia and eclampsia, and preeclampsia or eclampsia superimposed on preexisting hypertension. Severe preeclampsia and eclampsia had similar risk distributions and were combined into 1 group to stabilize estimates. Case definitions for hypertension were based on the *ICD-9-CM* codes recorded as discharge diagnoses: essential hypertension (642.0, 642.1, 642.2, 642.9, 401), gestational hypertension (642.3), preeclampsia (642.4), severe preeclampsia and eclampsia (642.5, 642.6), and preeclampsia or eclampsia superimposed on preexisting hypertension (642.7).

When multiple diagnoses for preeclampsia, severe preeclampsia, or eclampsia were listed, we categorized the hospitalization as the most severe form recorded. For other combinations of hypertension, we counted the hospitalization in each applicable category.

Race/Ethnicity and Residential Poverty

Hospital discharge records contained information on the patient's race and ethnicity (i.e.,

Hispanic or non-Hispanic). If Hispanic ethnicity was identified, it was maintained as the race/ethnicity of the patient. If a patient was identified as non-Hispanic, her race was categorized as non-Hispanic Black (Black), non-Hispanic White (White), or non-Hispanic other race (other).

Neighborhood poverty level was measured as the percentage of residents within each ZCTA living below the federal poverty line. This exposure was initially categorized into 6 groups: <2.5%, 2.5%–4.99%, 5%–9.99%, 10%–14.99%, 15%–19.99%, and ≥20% (i.e., federally defined poverty area).[28,29] Because of the small number of hypertensive hospitalizations in some subsets of race/ethnicity and neighborhood poverty, these 6 categories were condensed into 3 groups for the analyses: <10%, 10%–19.99%, and ≥20%.[29] Bias assessment identified no substantive residual confounding.

Potential Confounders and Effect Modifiers

Diabetes, considered a likely effect modifier, was categorized into 4 groups: type 1 diabetes, type 2 diabetes, gestational diabetes, and no diabetes. We further investigated the combination of gestational and type 2 diabetes, because diabetes diagnosed during pregnancy is often thought to be type 2 diabetes that is identified through prenatal testing.[30] Definitions for diabetes were based on *ICD-9-CM* codes as follows: type 1 diabetes (250, 250.0, 250.1, 250.2, 250.3, 250.4, 250.5, 250.6, 250.7, 250.8, 250.9, 250.01, 250.03, 250.11, 250.13, 250.21, 250.23, 250.31, 250.33, 250.41, 250.43, 250.51, 250.53, 250.61, 250.63, 250.71, 250.73, 250.81, 250.83, 250.91, 250.93), type 2 diabetes (250.00, 250.02, 250.10, 250.12, 250.20, 250.22, 250.30, 250.32, 250.40, 250.42, 250.50, 250.52, 250.60, 250.62, 250.70, 250.72, 250.80, 250.82, 250.90, 250.92), and gestational diabetes (648.8).

We obtained information about each patient's age and type of medical insurance from hospital discharge records. Age was categorized into 5 groups: 15 to 17, 18 to 19, 20 to 34, 35 to 44, and 45 to 54. Medicaid status was defined as being insured by Medicaid or enrolled in a Medicaid health maintenance organization. Because having no health

insurance usually indicates both low income and delayed application to Medicaid for pregnant women,[31] we combined women whose discharge records indicated self-pay as the method of payment (<5%) with women whose services were covered by Medicaid for our analyses.

Finally, we stratified all analyses in the study by the geographic region of residence as indicated by the county of residence on the hospital discharge record. NYC included the city's 5 counties: Bronx, Kings (Brooklyn), New York (Manhattan), Queens, and Richmond (Staten Island). NYS included all other counties grouped together.

Data Management and Statistical Analysis

We conducted all data management and statistical analyses using SAS software version 8.2 (SAS Institute Inc, Cary, NC). We linked hospitalization record zip code data with US Census ZCTA data. We calculated hospitalization rates for each of the 5 hypertension outcomes by combinations of race/ethnicity and residential poverty level and by diabetes and demographic factors. We assessed the 10-year trends of hospitalization rates with hypertensive disorders overall and separately for combinations of age group, region, racial/ethnic group, and diabetes status. We conducted stratified analyses for rates of hospitalizations with delivery by diabetes status, region, racial/ethnic group, age group, and residential poverty level. We calculated rate ratios for combinations of exposure factors and effect modifiers using both stratified analysis and logistic regression. Hereafter, the term "rate" refers to number of events per 100 hospitalizations with delivery unless otherwise stated.

RESULTS

The rates of gestational hypertension, preeclampsia, and eclampsia were highest in both the youngest (15 to 17) and the oldest (45 to 54) women, whereas increased age was positively associated with the rate of essential hypertension (Table 1). Women with a diagnosis of diabetes (gestational, type 1, or type 2) had increased rates of diagnoses for all forms of hypertension studied compared with those without diabetes diagnoses.

TABLE 1—Rates of Hypertensive Disorders During Pregnancy: New York State, 1993–2002

	N	Essential Hypertension	Gestational Hypertension	Preeclampsia	Preeclampsia Superimposed on Pre-Existing Hypertension	Severe Preeclampsia and Eclampsia	Total
Incidence	2 571 069	1.2	1.5	2.4	0.3	0.8	6.1
Age, y							
15-17	80 550	0.6	1.8	4.3	0.2	1.3	7.9
18-19	143 128	0.6	1.6	3.5	0.2	1.1	6.6
20-34	1 915 272	1.0	1.5	2.2	0.3	0.8	5.6
35-44	427 932	2.4	1.8	2.4	0.7	1.0	7.9
45-54	4187	5.6	3.1	5.0	2.0	2.1	17.2
Race/ethnicity							
White	1 297 460	1.1	1.8	2.0	0.2	0.7	5.5
Other	512 653	1.1	1.2	2.3	0.3	0.9	5.5
Hispanic	310 858	0.9	1.2	3.0	0.3	1.0	6.2
Black	450 098	2.1	1.5	3.3	0.7	1.2	8.5
Location							
NYC	1 206 454	1.3	1.1	2.8	0.4	0.9	6.3
NYS	1 364 615	1.2	2.0	2.0	0.2	0.8	6.0
Medicaid recipient							
No	1 054 022	1.2	1.8	2.0	0.3	0.8	5.9
Yes	1 517 047	1.2	1.4	2.6	0.3	0.9	6.3
Percentage below poverty in residential zip code							
0-9.99	981 708	1.1	1.8	2.0	0.2	0.7	5.6
10-19.99	778 799	1.2	1.6	2.4	0.3	0.8	6.2
≥20	810 562	1.3	1.2	2.9	0.4	1.0	6.6
Diabetes status							
No diabetes	2 458 303	1.1	1.5	2.3	0.3	0.8	5.8
Gestational diabetes	102 485	3.8	3.1	4.1	0.9	1.2	12.7
Type 2 diabetes	3509	9.6	2.7	5.4	2.7	2.1	21.2
Gestational and/or type 2 diabetes	105 994	4.0	3.1	4.2	0.9	1.3	13.0
Type 1 diabetes	6772	8.1	3.5	7.9	2.6	3.6	24.5

Note. NYC = New York City; NYS = New York State, excluding NYC. "Rate" refers to the number of events per 100 hospitalizations with delivery.

Women with a diagnosis of type 1 diabetes were most likely to have diagnoses of all forms of hypertension except essential hypertension (Table 1).

Analyses assessing associations between race/ethnicity and residential poverty with hypertension hospitalization showed similar results for preeclampsia and for all hypertension combined. For simplicity and clarity, we have chosen to present results focused on preeclampsia rates and will state when results varied for other hypertensive diagnoses.

Among nondiabetics, differences in preeclampsia rates by race/ethnicity were pronounced in NYC, with higher rates among Black women (3.2) and Hispanic women (2.9) than among White women (1.8), regardless of neighborhood poverty level (Figure 1a). Only among Hispanic women did a clear association exist between neighborhood poverty level and preeclampsia rates; in residential areas with poverty <10%, 10%–19.99%, and ≥20%, the preeclampsia rates were 2.5, 2.8, and 3.0, respectively. Outside NYC, smaller differences in preeclampsia rates by race/ethnicity occurred across all residential poverty levels. The association between residential poverty and preeclampsia rates among Hispanic women was not evident (Figure 1b); however, small sample sizes limited precision.

Black and Hispanic women who lived outside NYC resided largely in urban counties (87% of hospitalizations with delivery for Black women and 91% for Hispanic women), whereas White women lived in both urban (61%) and rural (39%) areas. The rates for preeclampsia among women residing in urban cities outside NYC (1.9 for White women, 2.4 for Black women, and 1.8 for Hispanic women) were similar to those among women in less densely populated areas outside NYC (1.9, 2.4, and 1.8, respectively, in suburban areas, and 2.2, 2.1, and 2.1, respectively, in rural areas). These preeclampsia rates were lower than the preeclampsia rates in NYC for all groups except White women.

Not only were the rates of preeclampsia among Black women substantially higher than the rates among White women across all urban areas of NYS, but the racial disparity increased over the decade. For the years 1993 through 1996, the average difference in preeclampsia rates in NYC for nondiabetics aged 20–34 was 1.2; the rate for Black women was 3.2, whereas the rate for White women was 2.0. For 1999 through 2002, the average difference increased to 1.7; the rate for Black women was 3.4, whereas the rate for White women was 1.7 (Figure 2a). Smaller but substantial differences between hypertension rates of Hispanic and White women were identified over time in NYC.

Similar trends occurred in the rest of NYS, though the disparities were less dramatic. Outside NYC, preeclampsia rates for Hispanic women decreased to the level for White women outside NYC by the end of the decade (Figure 2b). These patterns were also seen when all hypertensive disorders were combined and when diabetics were evaluated (data not shown). We assessed trends of hypertension rates in large hospitals to determine if the observed racial disparities were because of a change in diagnostic pattern; no change in diagnostic pattern was evident (data not shown).

Diagnoses of diabetes were more common among Black and Hispanic women than among White women across NYS, putting these 2 groups at higher risk of preeclampsia.

a

b
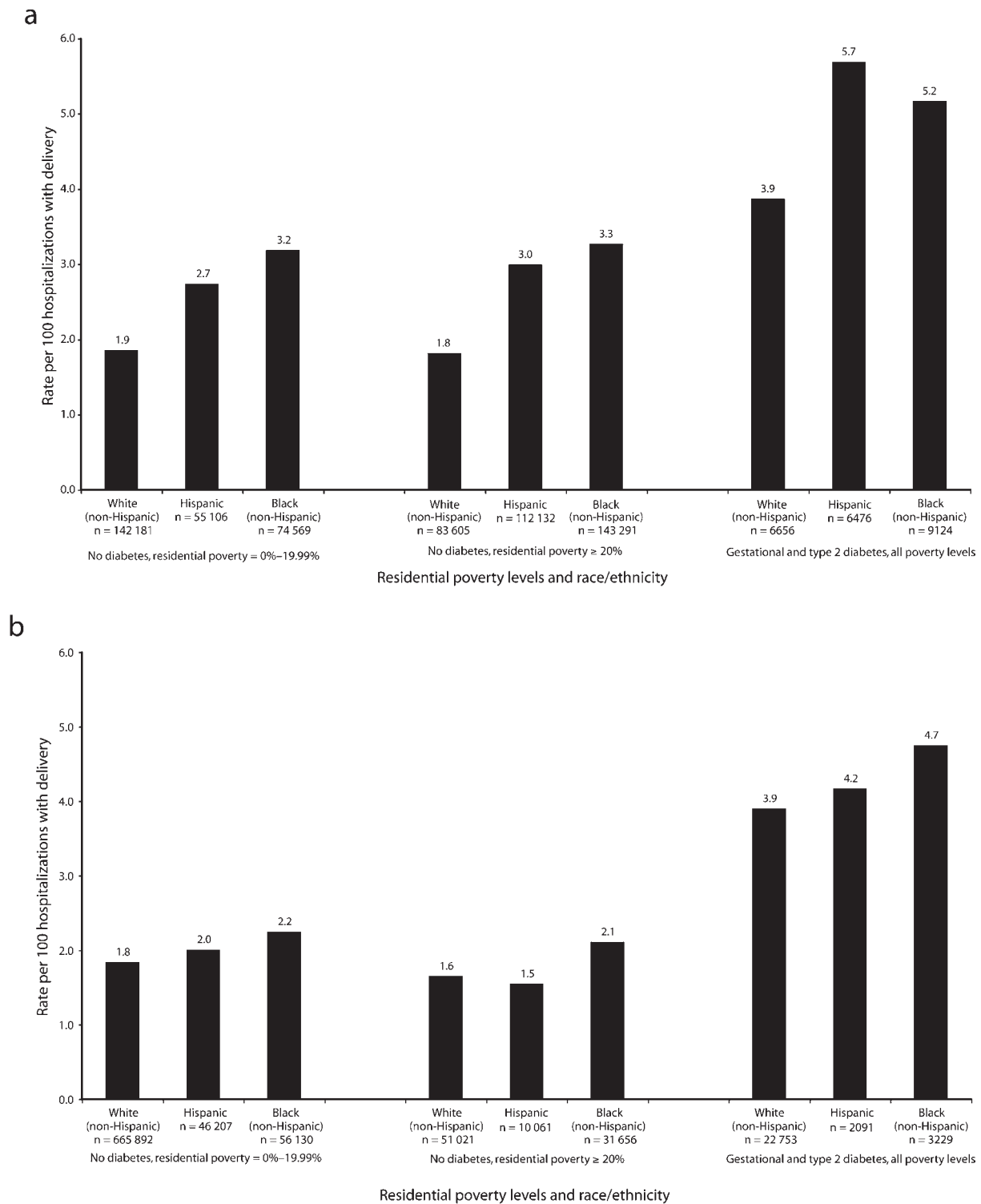
Note. Similar patterns were seen in other age groups. Rates of diabetics per 100 hospitalizations with delivery in New York City were: Whites = 2.9; Hispanics = 3.9; Blacks = 4.2. Rates of diabetics per 100 hospitalizations with delivery in New York State excluding New York City were: Whites = 3.2; Hispanics = 3.7; Blacks = 3.7.

FIGURE 1—Rates of preeclampsia for women aged 20–34 years, by race/ethnicity, residential poverty, and diabetes status, in New York City (a) and New York State excluding New York City (b): 1993–2002.

a

b
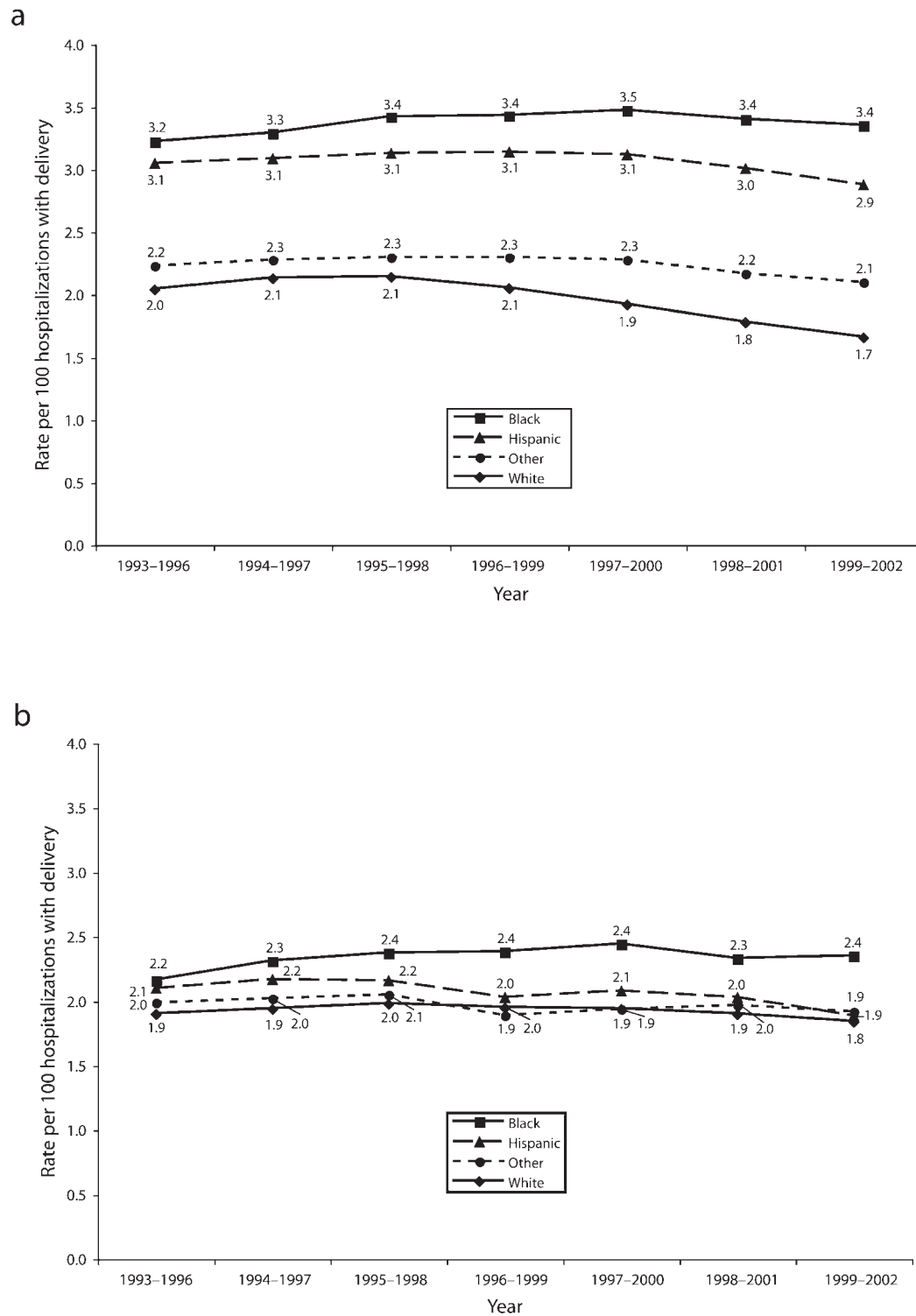
FIGURE 2—Rolling average rates of preeclampsia by race/ethnicity among nondiabetic women aged 20–34 years, New York City (a) and New York State excluding New York City (b): 1993–2002.

Among hospitalizations with diagnoses of diabetes in NYC, Hispanic women had a notably higher rate of preeclampsia, followed by Black women, then White women (Figure 1a). In the rest of NYS, the differences in preeclampsia rates among diabetics by race/ethnicity were smaller (Figure 1b).

Application of a multivariate logistic regression model similar to those previously reported[21,24] showed that the model poorly fit NYS data. Thus, we used stratified analyses for calculation of rates and rate ratios of preeclampsia. The relation between race/ethnicity and preeclampsia occurred in diabetics as well as nondiabetics in NYC, although small numbers limited interpretation (data not shown).

DISCUSSION

We found increasing racial disparities in maternal hypertension rates over the past decade in NYS. This finding was strengthened when further analyses focused specifically on preeclampsia hospitalizations among nondiabetic women aged 20 to 34 to remove potential confounding associated with age, diabetes status, and mixed forms of hypertension. Not only did higher rates of preeclampsia exist among Black women hospitalized with delivery than among White women, but this difference appeared to be increasing. Over the same time period, the rate of hospitalization with delivery for women living in poor areas remained relatively constant within racial/ethnic groups and geographic regions (data not shown); this partially removes changes in SES as a cause of the increasing disparity.

Preeclampsia rates were much higher in NYC than in the rest of NYS for Black and Hispanic women, but not for White women. Our study could not fully explain the greater racial/ethnic disparities in rates of preeclampsia and all hypertensions combined in NYC by the maternal characteristics we studied.

One possible explanation may be that disparities across social gradients are greater in major urban areas.[32,33] Our assessment of the association between preeclampsia rates in urban areas outside NYC showed relatively similar rates in rural and urban regions. No clear trends among Black and Hispanic women across rural areas could be assessed because of the small population sizes outside cities. Evaluation of differences in diagnostic rates for the largest hospitals in each region ruled out a second possible explanation: variations in diagnosis and recording procedures.

A third potential reason for the differences between NYC and the rest of NYS is differences in the cost of living. The cost of living in NYC is more than 50% greater than it is upstate[34]; it may be that in NYC we identified predominately minority residential areas with substantially lower poverty levels than areas in the remainder of the state. Percentage below the federal poverty level is considered a strong measure of residential SES in population-based research.[35] However, because federal poverty computations are not adjusted for cost of living, the effect of poverty level on hypertension rates may vary by region. Although longitudinal findings within NYC and outside NYC likely are reasonable, comparisons of NYC with the rest of NYS without cost-of-living adjustments should be performed cautiously.

Preeclampsia rates among Hispanic women are somewhat complex, potentially because of the distribution of Puerto Rican and other Hispanic women living across NYS, because a disproportionate number reside in NYC compared with NYS; regional variation of lifestyles; environmental factors; or other factors. In NYC, Hispanic women had preeclampsia rates approaching those of Black women among nondiabetics and exceeding those of both White and Black women among diabetics. This finding held regardless of poverty level. In the rest of NYS, Hispanic women had preeclampsia rates similar to those of White women. In national studies, Hispanic women have been found to have higher rates of obesity, insulin resistance, gestational diabetes, and type 2 diabetes compared with White women.[36,37] Additionally, Hispanic women appear to be more susceptible than Black women to gestational diabetes with both increasing maternal age and increasing BMI.[38] Hispanic women also have shown faster progression from the first manifestation of gestational hypertension to preeclampsia compared with White women.[7,39] Additional studies that focus on the experiences of Hispanic women are needed.

Hospitalization for delivery with a diagnosis of diabetes was more common among Black and Hispanic women than among White women. Associations between gestational diabetes and hypertension in pregnancy seen in this study have been previously identified in both population-based[10,21,23,24] and clinical[1,40] studies. When we controlled for age and residential poverty, gestational diabetes approximately doubled the risk of preeclampsia across racial/ethnic groups. This finding was similar to some previous studies[10,21,23] but different from a population-based study conducted among Washington State residents with driver's licenses, which found that gestational diabetes increased the risk of preeclampsia among Black women more substantially than among White women.[24] Important differences in study designs, including sample selection and available information on confounders, make it difficult to directly compare the results.

Maternal obesity has been treated as a confounder in several studies of gestational diabetes and preeclampsia.[10,23,24,41] Although our study does not have a measure of BMI, we do not consider this a substantial limitation. We contend that obesity and diabetes are both partially on the causal pathway and may operate as effect modifiers between poverty and race/ethnicity–related experiences (e.g., racism) and pregnancy-related hypertension.

Among nondiabetics and particularly in NYC, we saw an increase over time in the disparity between Black and White women in rates of preeclampsia and overall hypertension. Reviewing the potential causes for these trends, we suggest that obesity may be partially related. Although the etiology of preeclampsia is not clearly established,[2] clinical studies suggest that increased insulin resistance, more common among the obese, may be a mechanism for increased risk of preeclampsia and hypertension among nondiabetics.[42–47] Obesity was found to be an independent risk factor for preeclampsia in several studies that controlled for diabetes.[48–51] The prevalence of obesity in the United States in 2000 was higher among Black women (49.7%) than among White women (30.1%) or Hispanic women (39.7%).[52] Trends in obesity over the past decade have shown a larger percentage increase from 1988 to 2000 among Black women (11.5%) than among White women (4.4%) or Hispanic women (7.2%).[52]

To support our assertion that obesity was increasing in NYS, we reviewed data from the Pregnancy Risk Assessment Monitoring System (PRAMS) for NYS excluding NYC.[53] The proportion of prepregnancy obesity (BMI>29 kg/m^2) was higher in Black women (19%) than White women (11%) in the period from 1993 to 1994. The racial disparity in prepregnancy obesity became greater by the period 2000 through 2002 in NYS (obese Blacks=25%; obese Whites=14%; New York State Department of Health, written communication, February 2005). Recent research suggests that contextual factors, such as the distribution of fast-food establishments, may contribute to differences in obesity by race/ethnicity.[54]

Differences in entry into prenatal care may partially explain the racial differences in hypertension seen in this study. Although more than 95% of women had insurance by the time of delivery, data from PRAMS suggest they may not have had this coverage early in pregnancy, an important distinction seen in other US studies.[31,53,55] For women living in NYS excluding NYC, 88.4% of White women reported receiving prenatal care initially in the first trimester, whereas only 74.8% of Black women and 69.3% of Hispanic women did so (New York State Department of Health, written communication, February 2005). Given that 76.6% of hospitalizations with delivery in NYC were covered by Medicaid or were self-paid, as opposed to 43.5% outside NYC, it may be that lack of early prenatal care was greater in the city. With early identification, gestational hypertension may be managed to reduce the risk of preeclampsia and eclampsia.

Limitations

Several caveats are noteworthy. This study lacks individual-level risk factors not contained in the hospital discharge database. Second, misclassification of race/ethnicity on hospital records is likely. However, this misclassification probably created a bias toward the null value; thus, the true relations are likely larger than presented. Third, validation studies of pregnancy-related hypertension are limited;[6] it is likely that some misclassification occurred. Because of the seriousness of preeclampsia, it is unlikely that underdiagnosis and underrecording are substantial. Study of the validity of hypertension recorded in discharge databases is

needed. Fourth, we did not consider births that occurred outside hospitals. In 2002, the percentages of births outside hospitals in NYS were 0.8%, 0.7%, and 0.5% for Whites, Blacks, and Hispanics, respectively, suggesting minimal effect on the estimates presented.[56] Fifth, we excluded hospital records with pregnancy loss or spontaneous or induced abortion (0.9%). Sixth, incorporation of Medicaid insurance status did not substantively improve insight based on the analyses presented. Because pregnant women with an income of less than 200% of the federal poverty level qualify for Medicaid in NYS, this dichotomous poverty measure obscures the true gradient of poverty. Our study partially overcame this problem by implementing a gradient based on the percentage of a zip code's population with income lower than the poverty level.[35]

Earlier research noted methodological issues related to using zip codes to approximate neighborhood SES.[57] Discrepancies of boundaries between patients' zip codes in hospital data and ZCTAs in the US Census may lead to bias in determining the residential poverty levels for some areas. Also, there is a potential misclassification of poverty level within zip code areas, because neighborhood poverty levels are not necessarily homogeneous within them.[58] These limitations likely lead to a bias toward the null.

Conclusions

Our study complements previous population studies of hypertension in pregnancy by including about 99% of deliveries in NYS. Using more than 2.5 million records over a decade created stable results in most instances and allowed us to assess associations between race/ethnicity, poverty, and pregnancy-related hypertension simultaneously. Understanding the growing trends in racial disparities seen in this study is worthy of further investigation. ∎

About the Authors

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Human Participant Protection
We analyzed a secondary data set without key identifiers available to the general public.

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